

# **MODEL VALIDATION AND EVALUATION IN THE GREENLAND-ICELAND-NORWEGIAN [ GIN ] SEA**

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# MODEL VALIDATION IN THE GIN SEA

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## Objectives:

- To formulate and test metrics for model evaluation making specific use of high quality hydrographic data
- To evaluate the usefulness of customary and novel metrics using model outputs in data rich regions
- To the extent feasible, utilize the same software to evaluate the climatological data sets used for model initialization and surface forcing

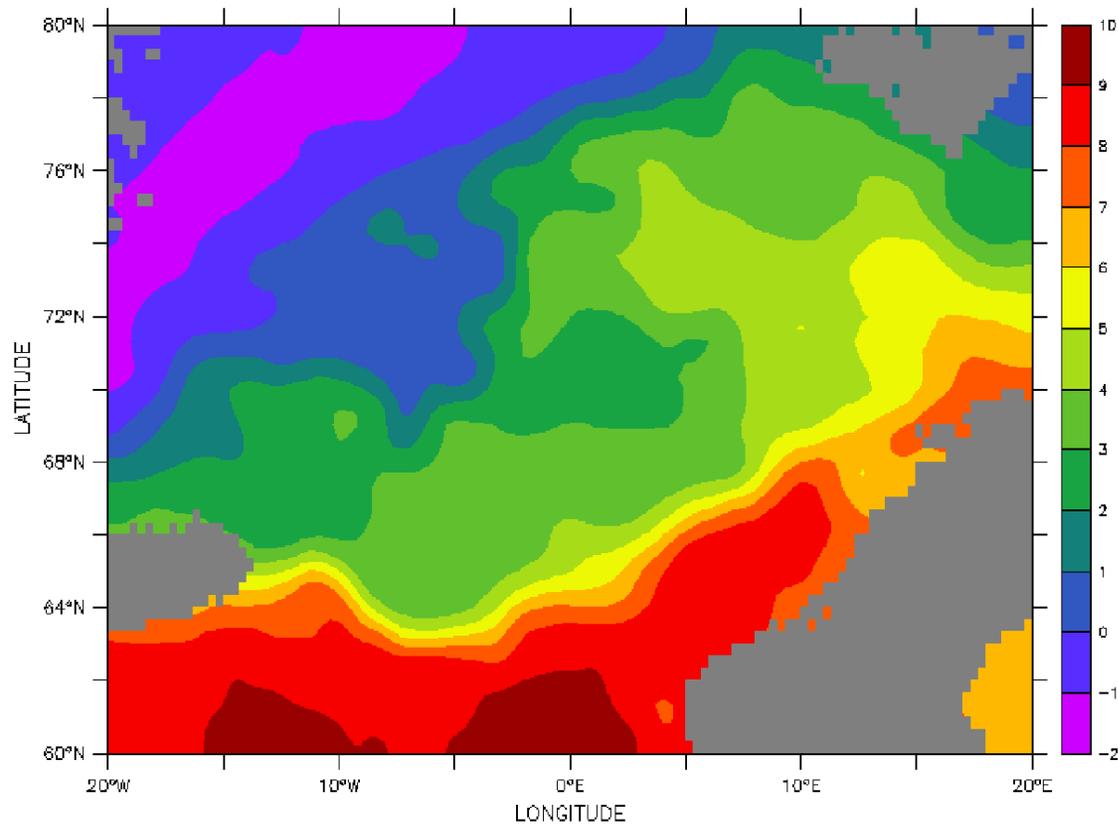
# MODEL EVALUATION IN THE GIN SEA

## POP 1/3 deg temperature: GIN Sea

FERRET (V800) (beta 1) Ver. 5.00  
NOV 17 2001 14:32:54

DEPTH (m) : 0

DATA SET: t\_gin\_sphere\_3802.nc



POP13\_Temp\_\_file\_3802 (deg)

# MODEL EVALUATION IN THE GIN SEA

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## Long Term Metrics

- **Time history of transports in passages, straits, major currents**
- **Watermass census**
- **Eddy energetics**
- **Location/depth of given isopycnals, isotherms**
- **Distribution of properties on isopycnals**
- **Meridional overturning**

# MODEL EVALUATION IN THE GIN SEA

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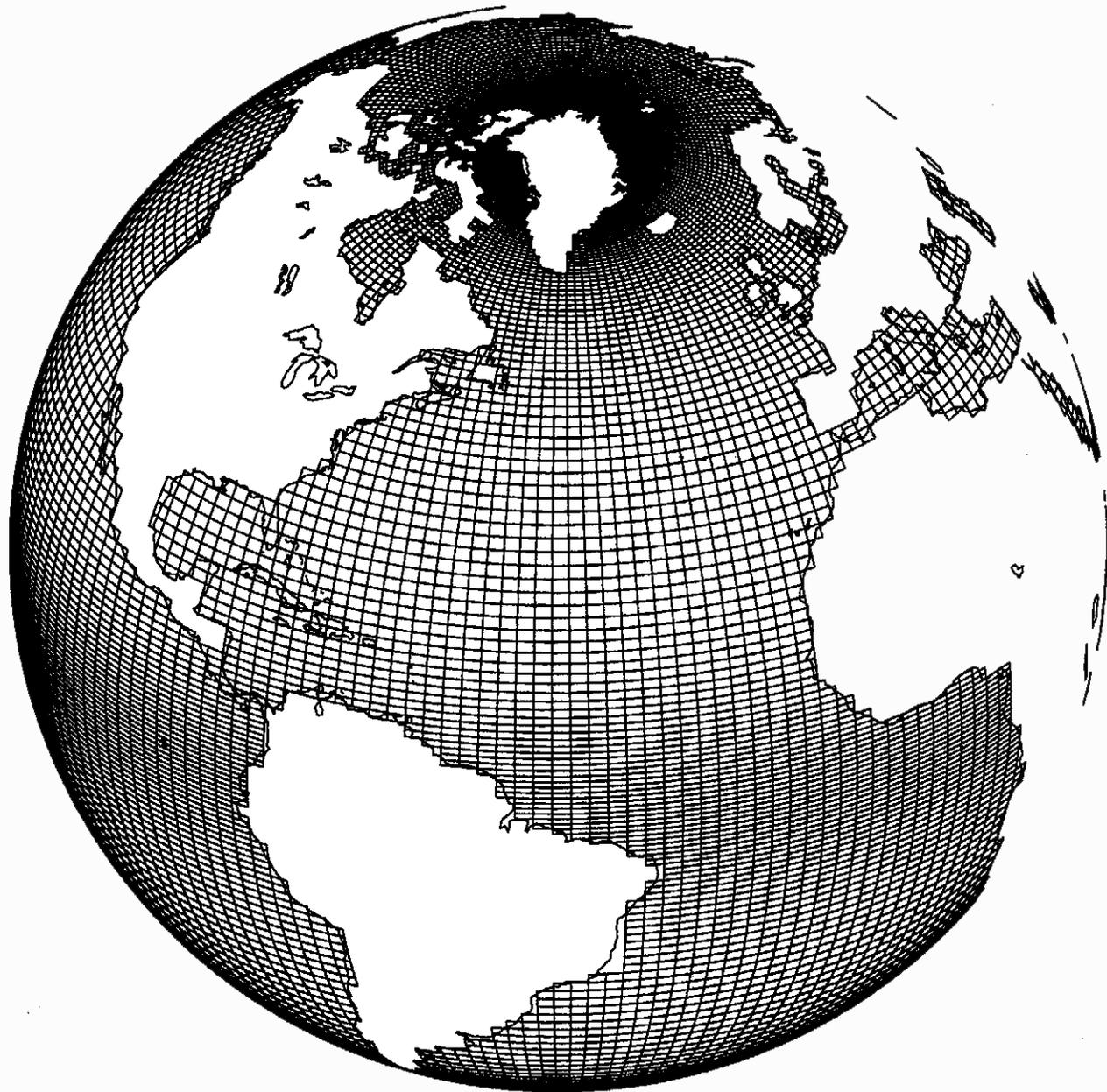
## “Synoptic” Metrics

- **RMS errors of SST: model vs. satellite, in-situ observations over days or weeks**  
globeaps
- **RMS errors of T and S profiles: model vs. in-situ observations; synthetic T, S; climatology**
- **Variability and standard deviation at given depth level: model vs. observations vs. climatology**

# POP MODEL DESCRIPTION

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- **1/3 deg global, pole stretched to Hudson Bay**
- **z-level (32) model, KPP mixing scheme**
- **daily ECMWF forcing [reanalysis: 79-93, operational 94-97] `globe.ps`**
- **accelerated temperature/salinity time marching during a 20-year spinup**
- **initialized with Levitus94 1-deg climatology**
- **surface S relaxed to Levitus with 90-day time constant, climatological ice cover**

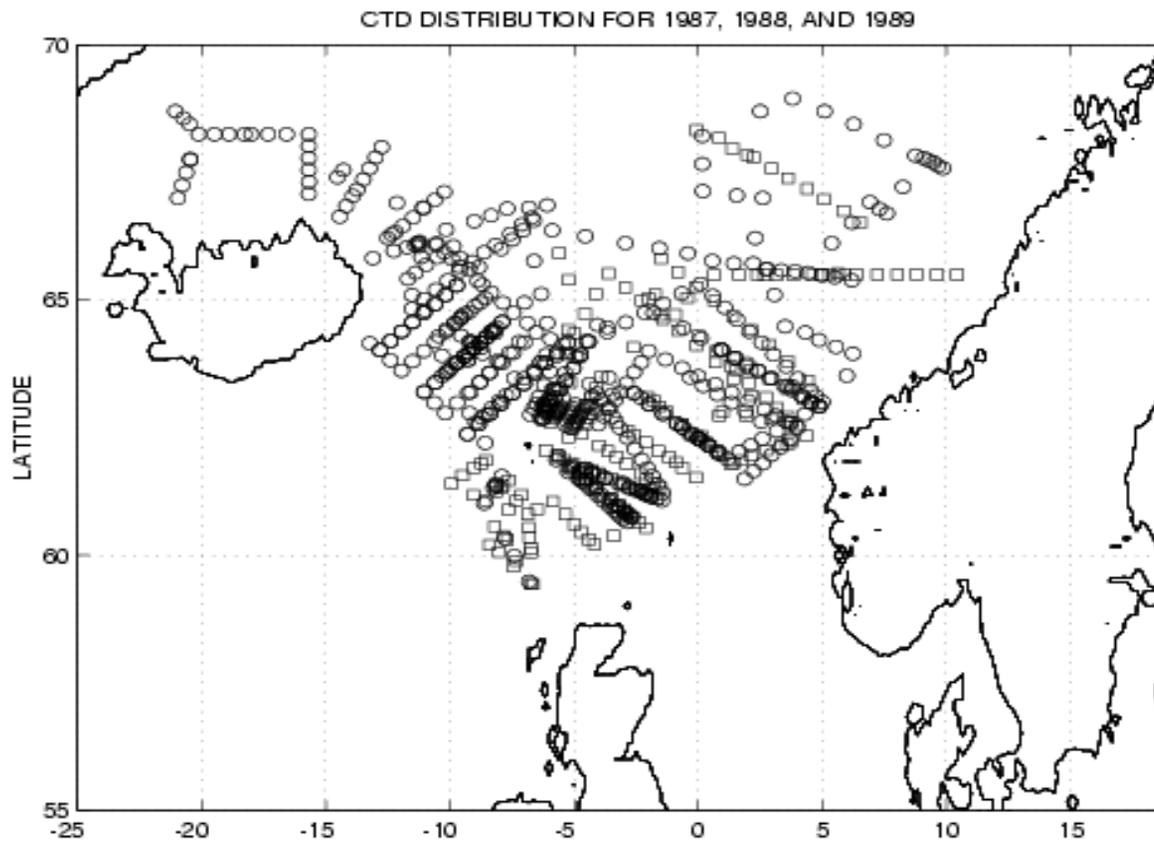


# DieCAST MODEL DESCRIPTION

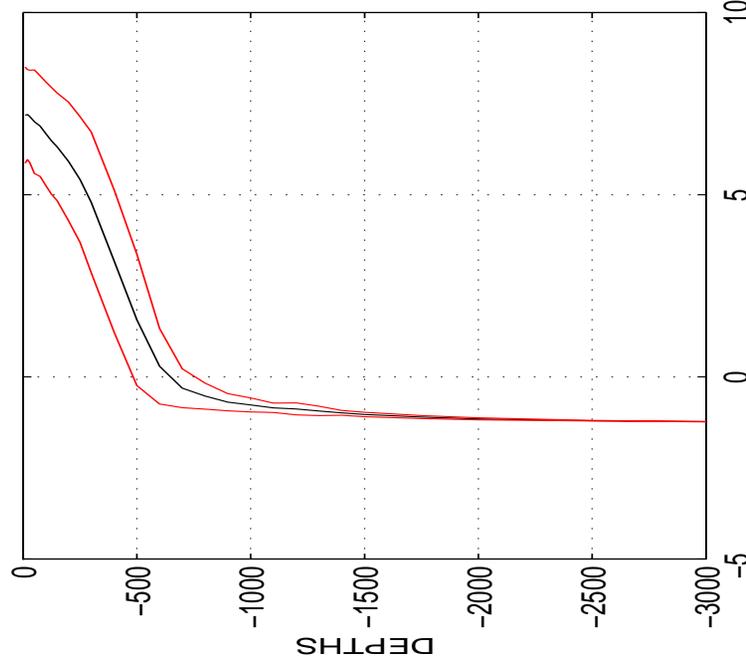
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- **Gaussian 1/2 deg grid, covering the North Atlantic/Arctic region [30N – 87.5N, 150W-90E]**
- **z-level (35) model, fixed mixing coefficients**
- **daily NCEP reanalysis forcing [1985-97]**
- **accelerated 1-year spinup with 1985 forcing**
- **initialized with Levitus94 1/4-deg climatology**
- **climatological SST and SSS restoring to seasonal Levitus; no ice cover**

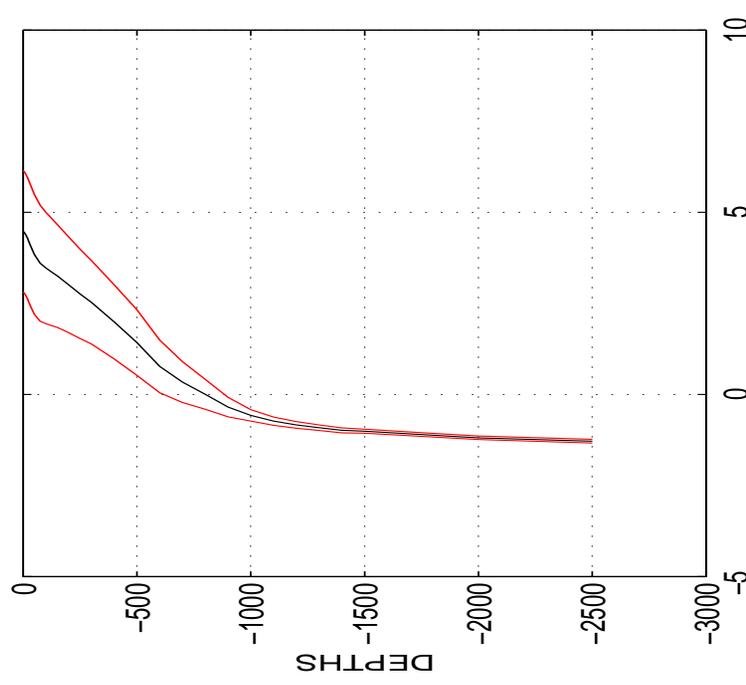
# 1986-89 CTD Station Distribution



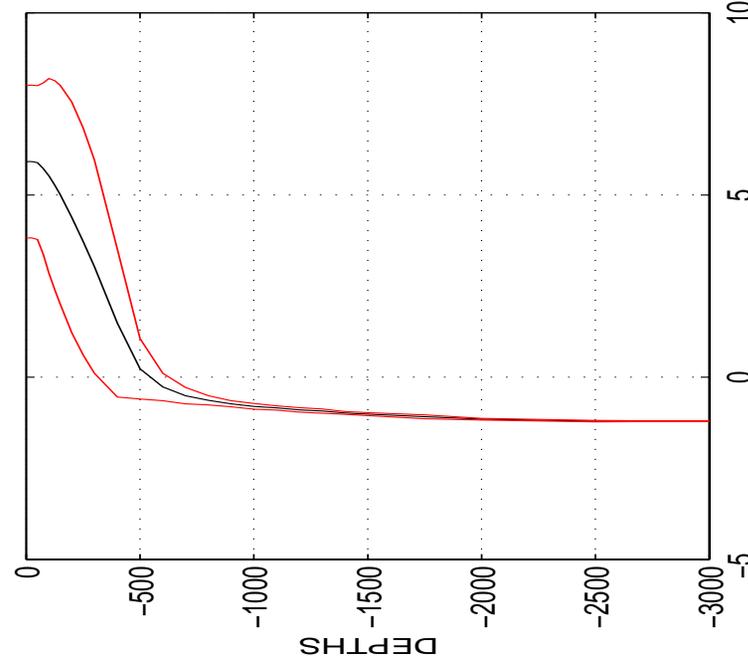
MAY 1987 CTD POT. TEMPERATURE



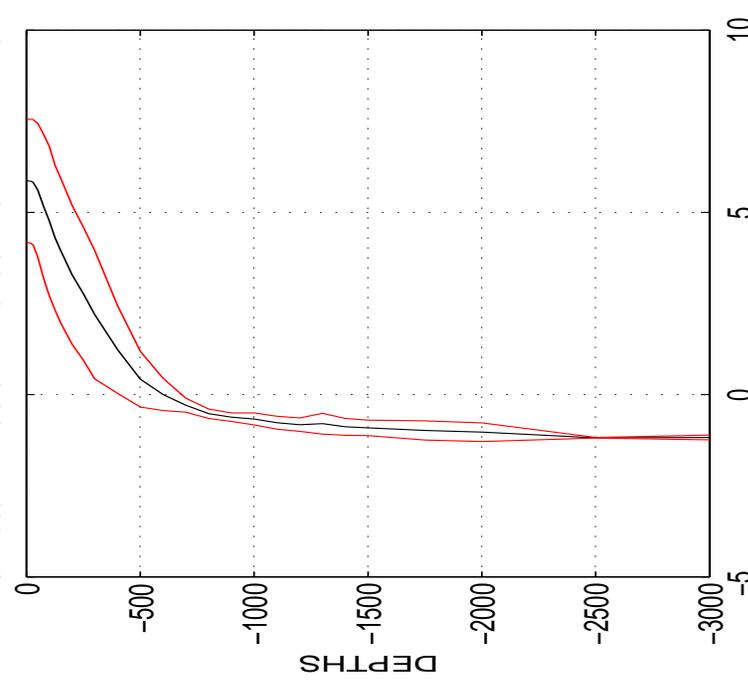
MAY 1987 LEVITUS CLIMATOLOGY POT. TEMPERATURE



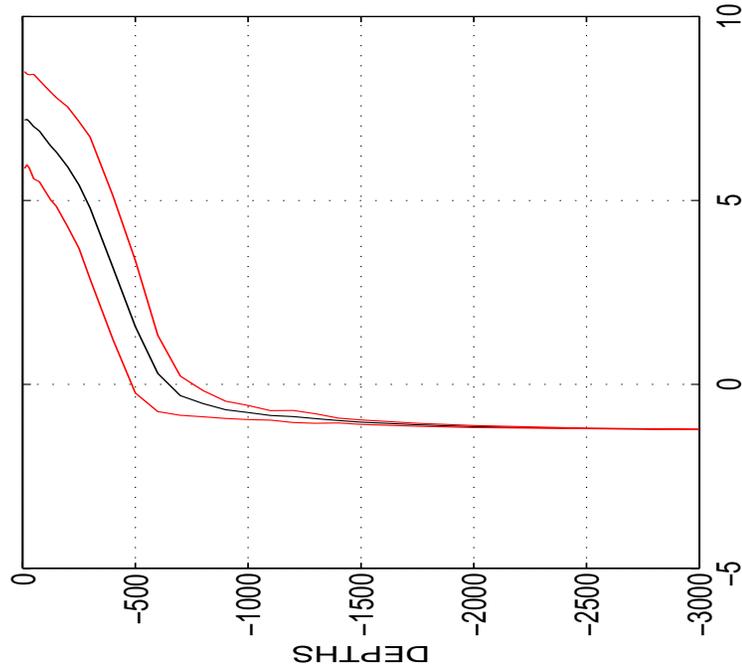
NOV 1988 CTD POT. TEMPERATURE



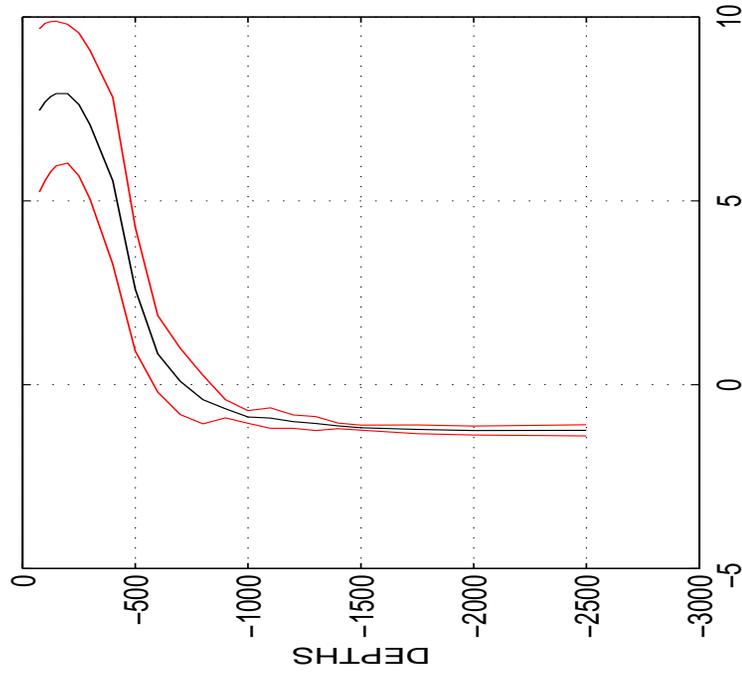
NOV 1988 LEVITUS CLIMATOLOGY POT. TEMPERATURE



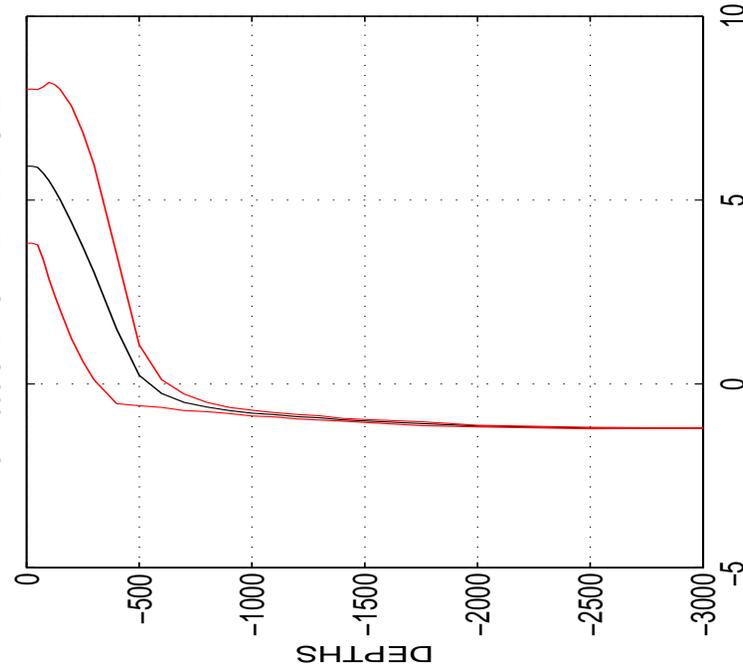
MAY 1987 CTD POT. TEMPERATURE



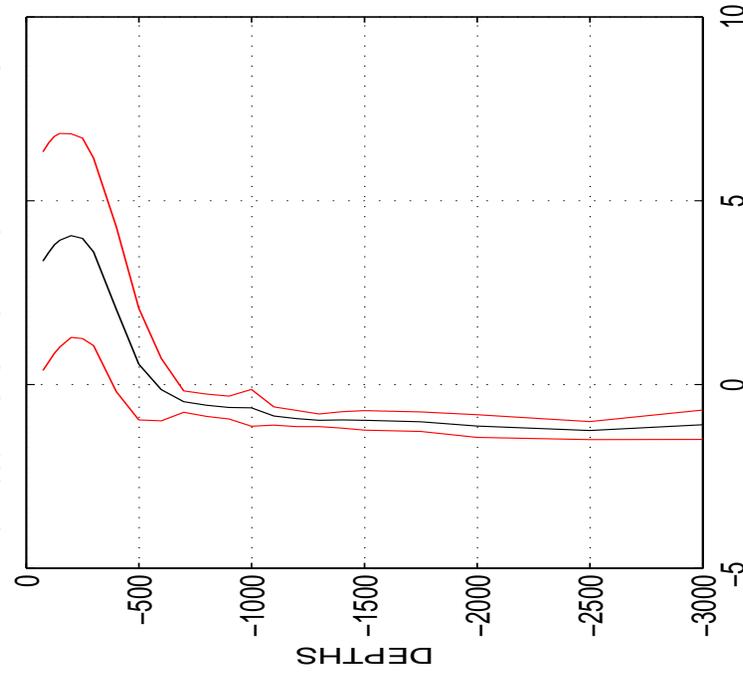
MAY 1987 DIECAST MODEL POT. TEMPERATURE



NOV 1988 CTD POT. TEMPERATURE



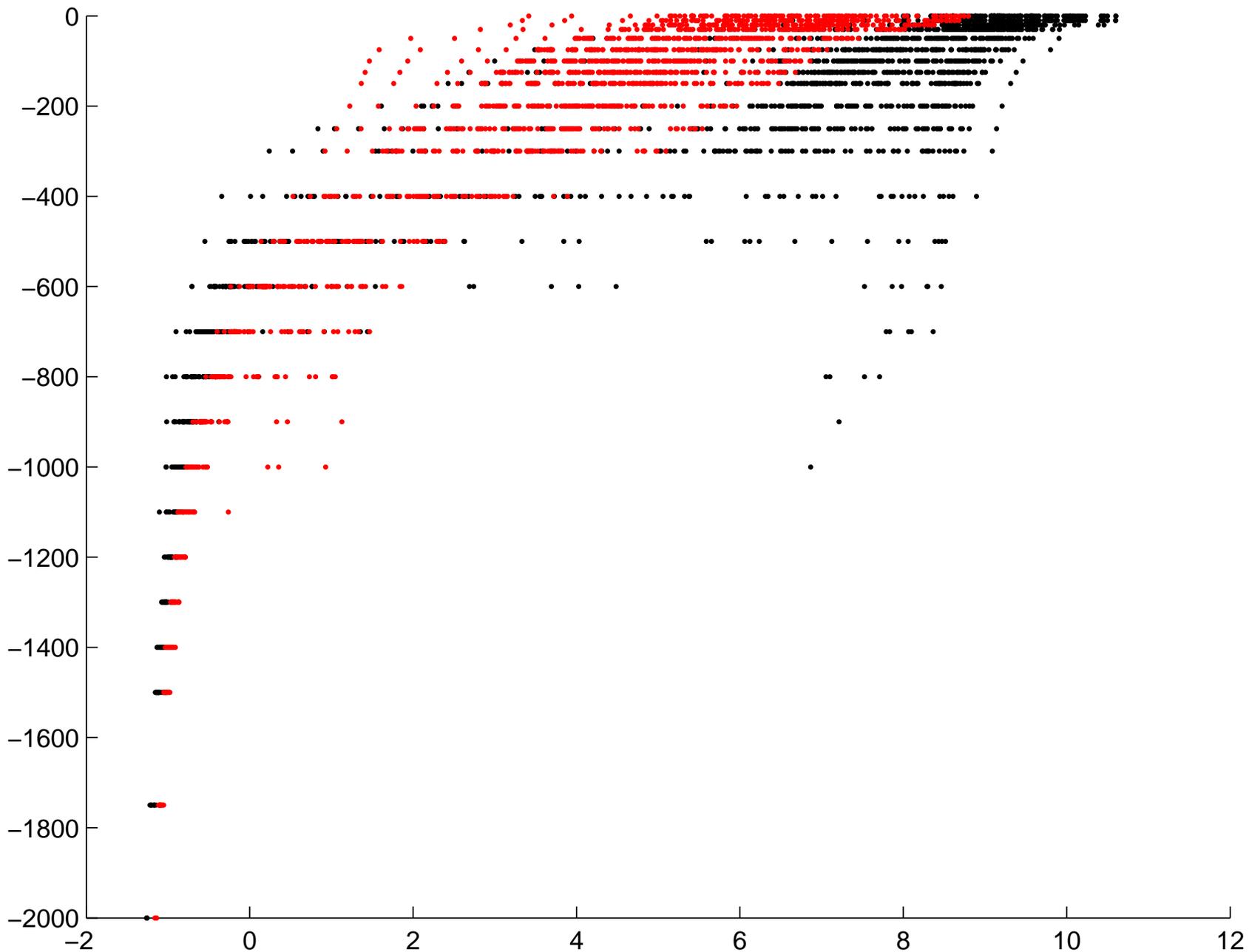
NOV 1988 DIECAST MODEL POT. TEMPERATURE



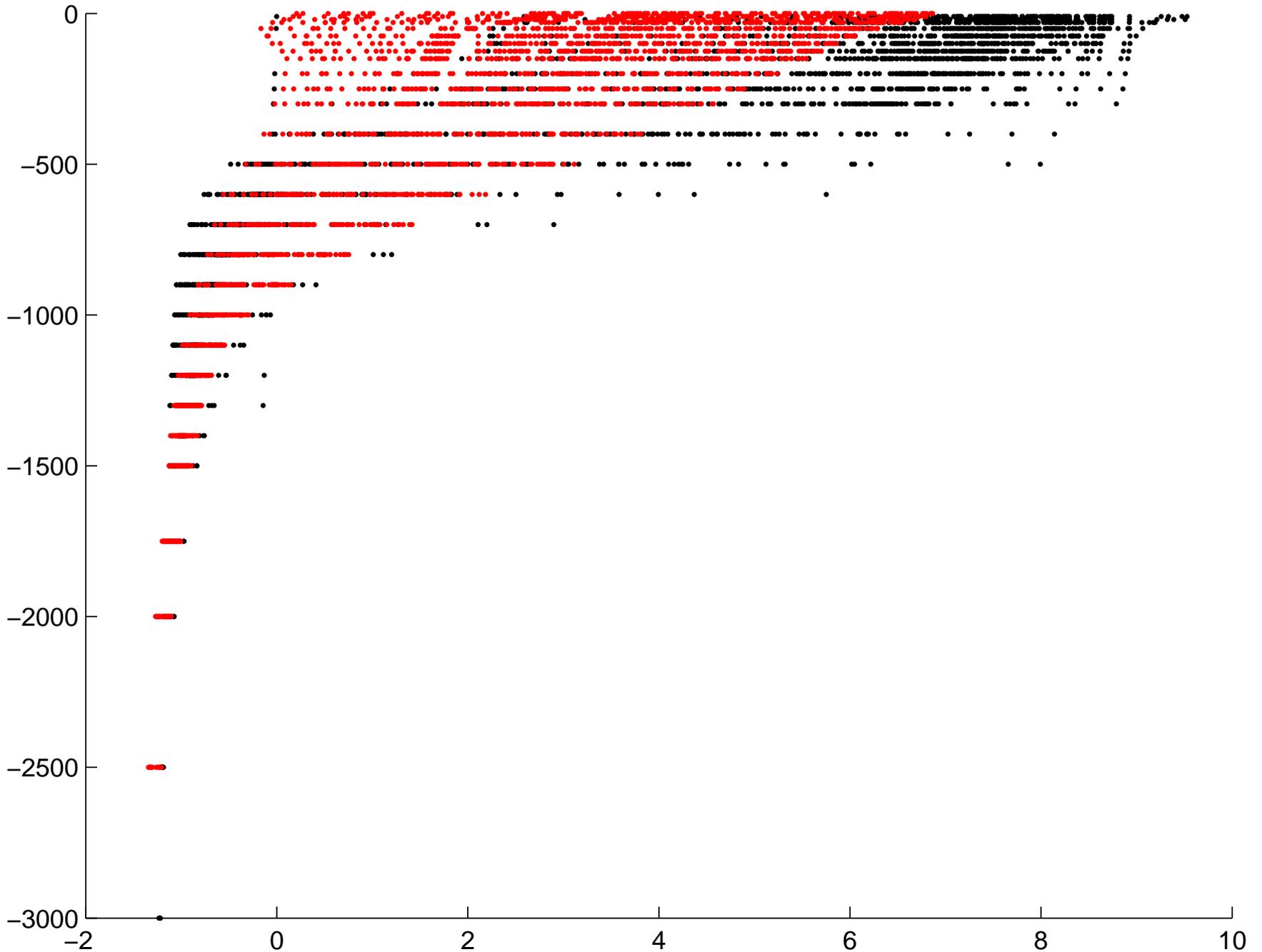
MEAN TEMPERATURE

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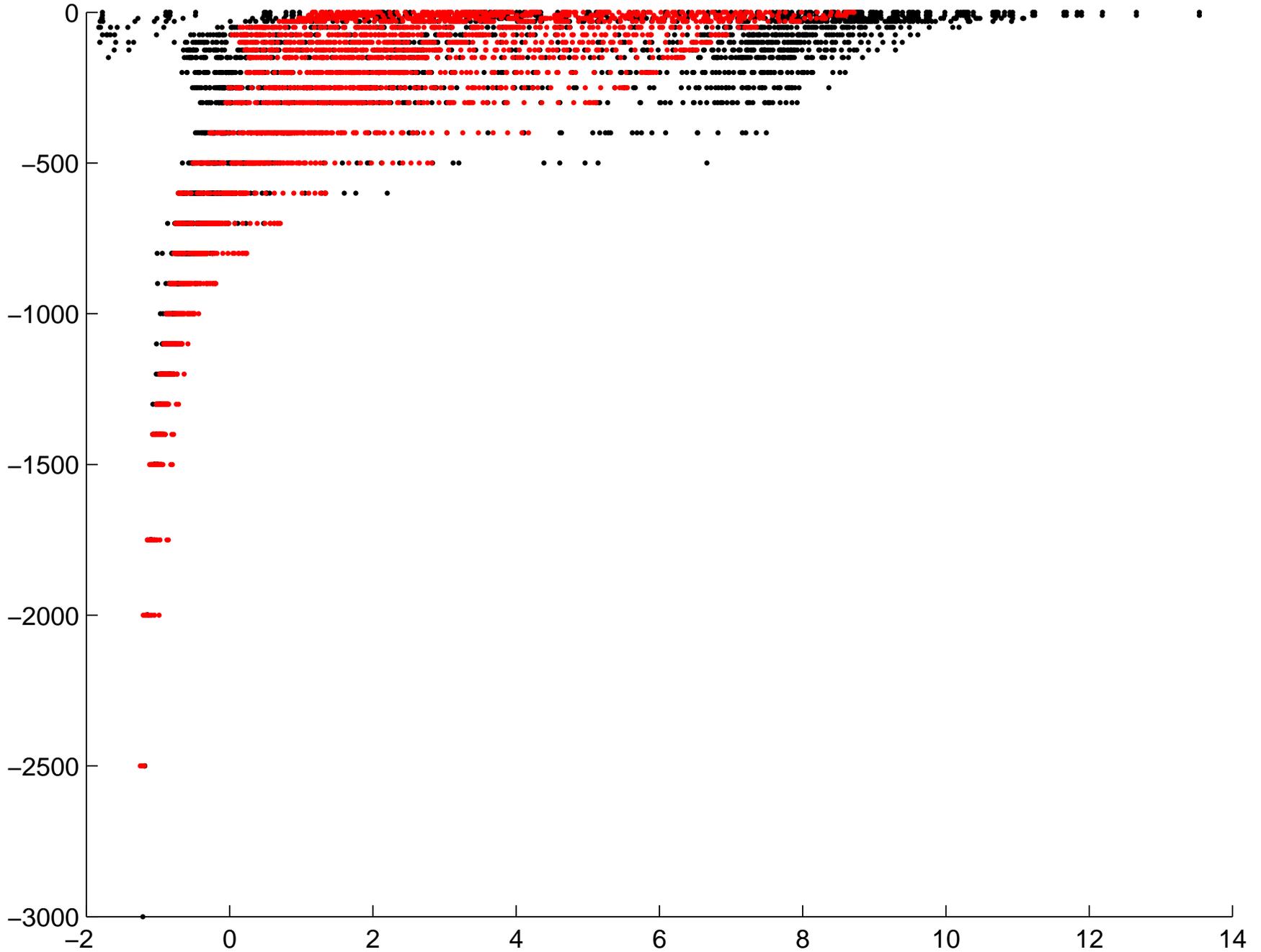
POTENTIAL TEMPERATURE (black=CTD, red=LEVITUS CLIMATOLOGY)  
1986/ 6 TO 1986/ 6



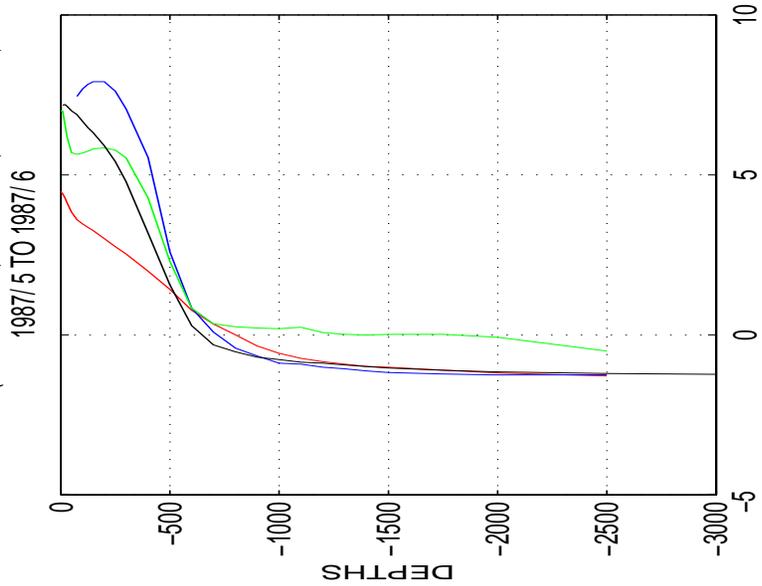
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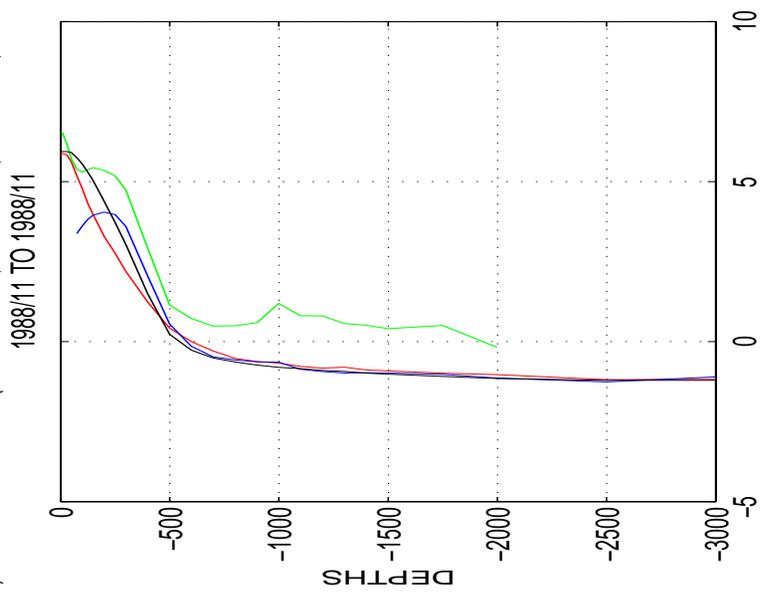
POTENTIAL TEMPERATURE (black=CTD, red=LEVITUS CLIMATOLOGY)  
1989/ 5 TO 1989/ 6



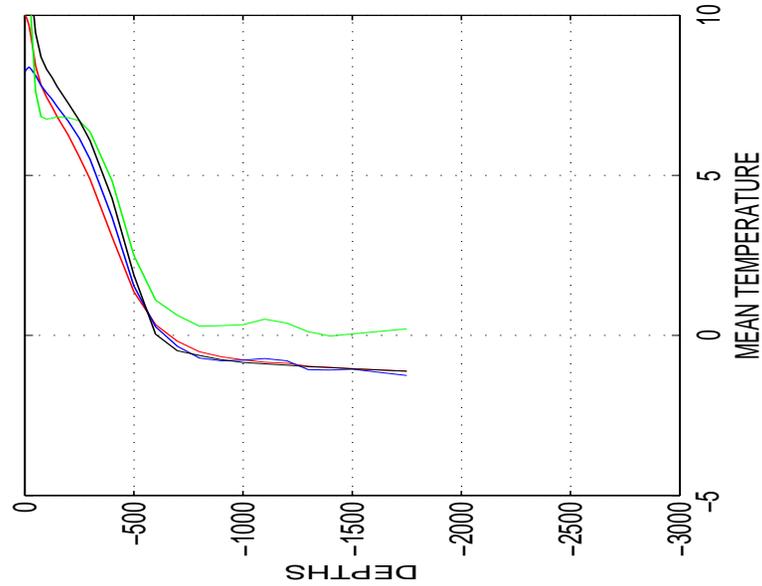
POT. TEMPERATURE (BLACK=OBS, RED=CLIM, BLUE=DIE, GREEN=POP). 1987/5 TO 1987/6



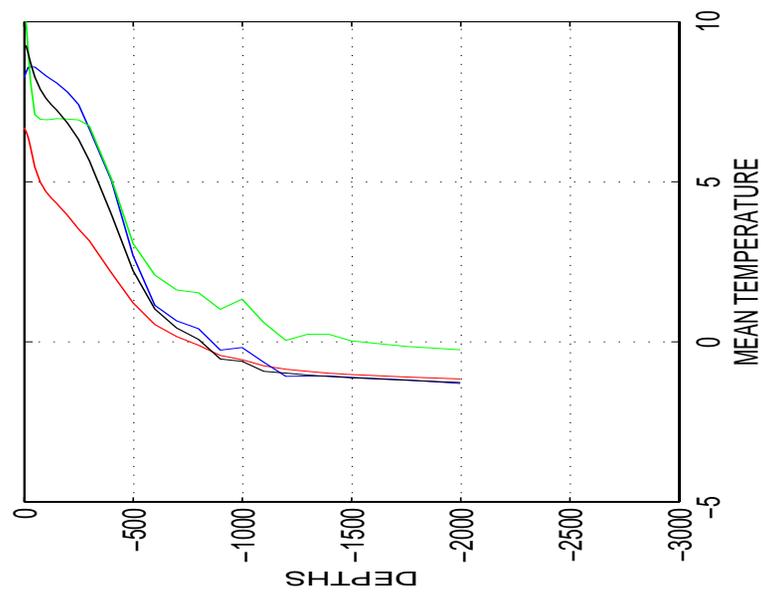
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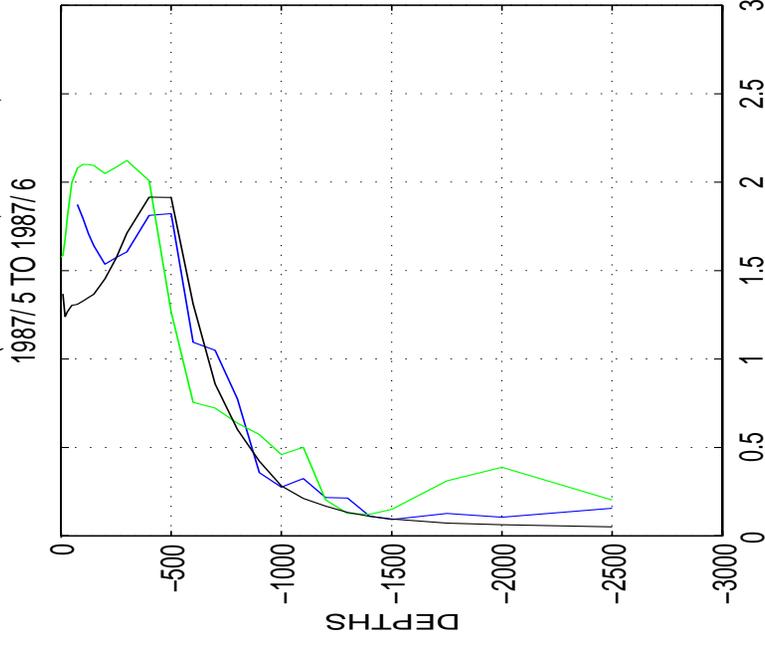
POT. TEMPERATURE (BLACK=OBS, RED=CLIM, BLUE=DIE, GREEN=POP). 1987/9 TO 1987/9



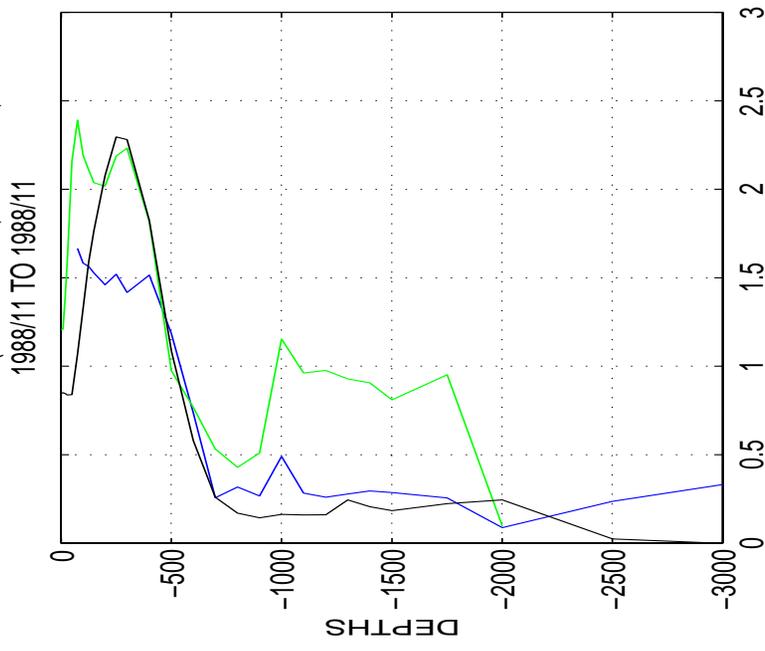
POT. TEMPERATURE (BLACK=OBS, RED=CLIM, BLUE=DIE, GREEN=POP). 1986/6 TO 1986/6



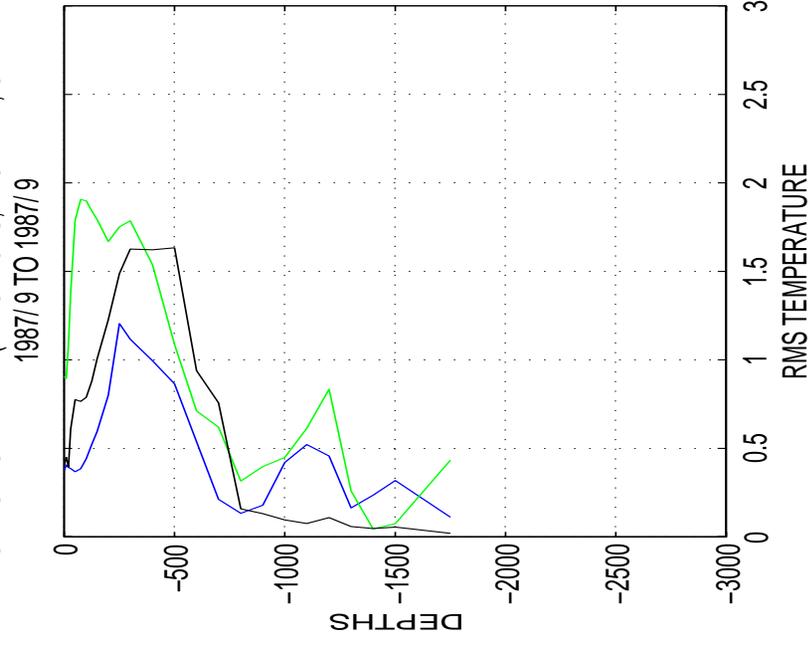
RMS RES. POT. TEMP. (BLACK=OBS, BLUE=DIE, GREEN=POP)



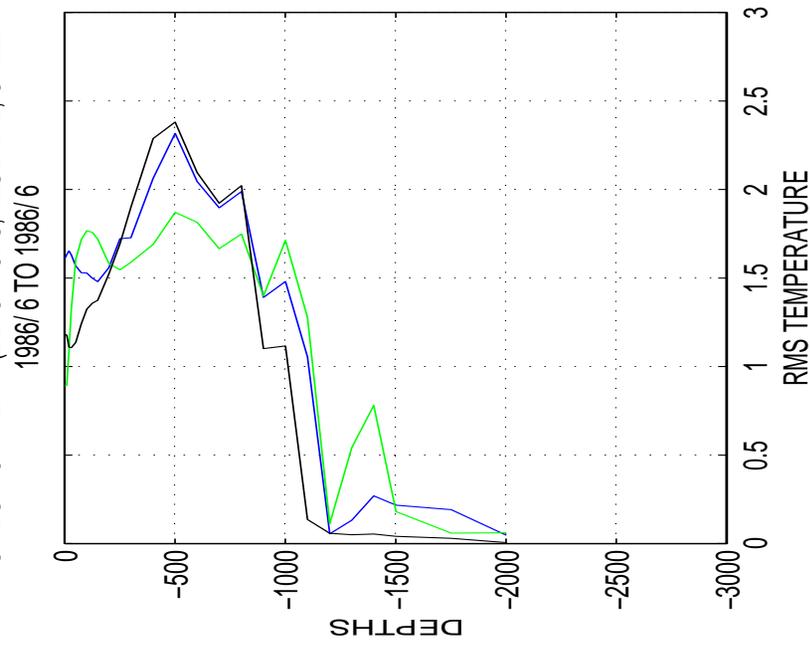
RMS RES. POT. TEMP. (BLACK=OBS, BLUE=DIE, GREEN=POP)



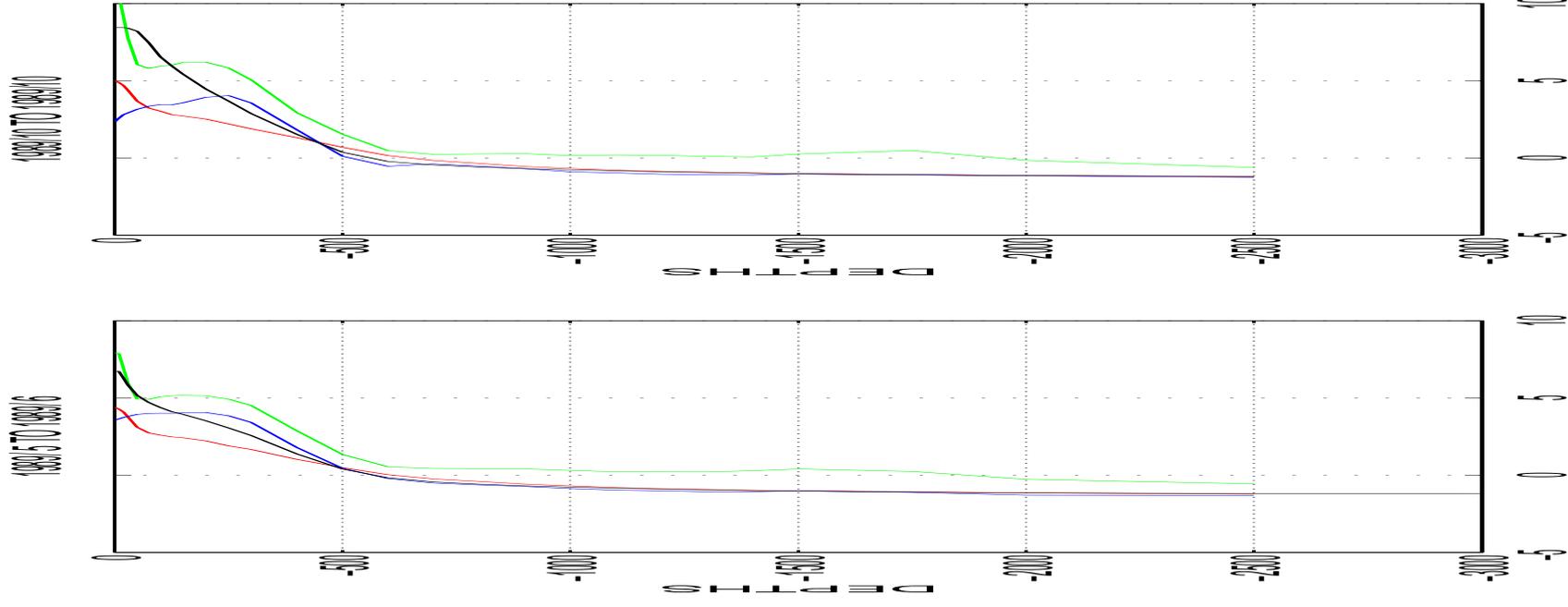
RMS RES. POT. TEMP. (BLACK=OBS, BLUE=DIE, GREEN=POP)



RMS RES. POT. TEMP. (BLACK=OBS, BLUE=DIE, GREEN=POP)

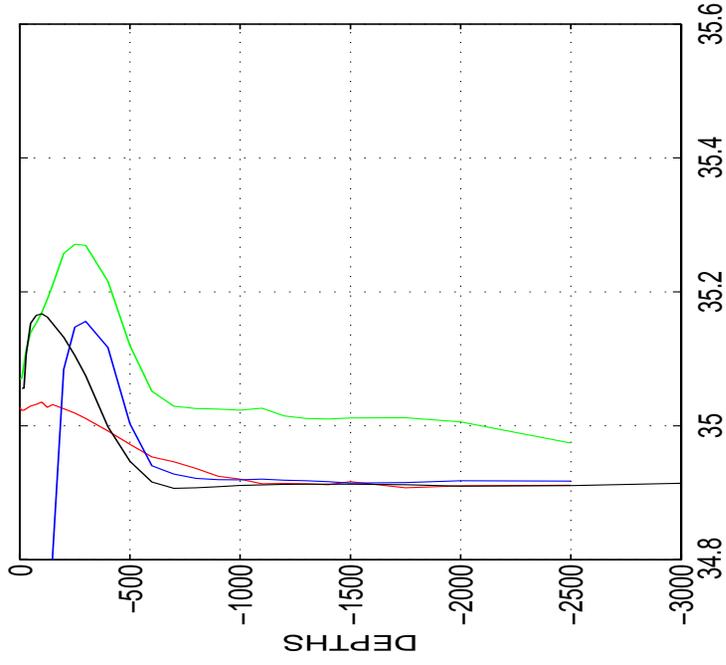


POT: TEMPERATURE BLUE=CO2 RED=CO2+O2 POT: TEMPERATURE BLUE=CO2 RED=CO2+O2 POT: TEMPERATURE BLUE=CO2 RED=CO2+O2 POT: TEMPERATURE BLUE=CO2 RED=CO2+O2

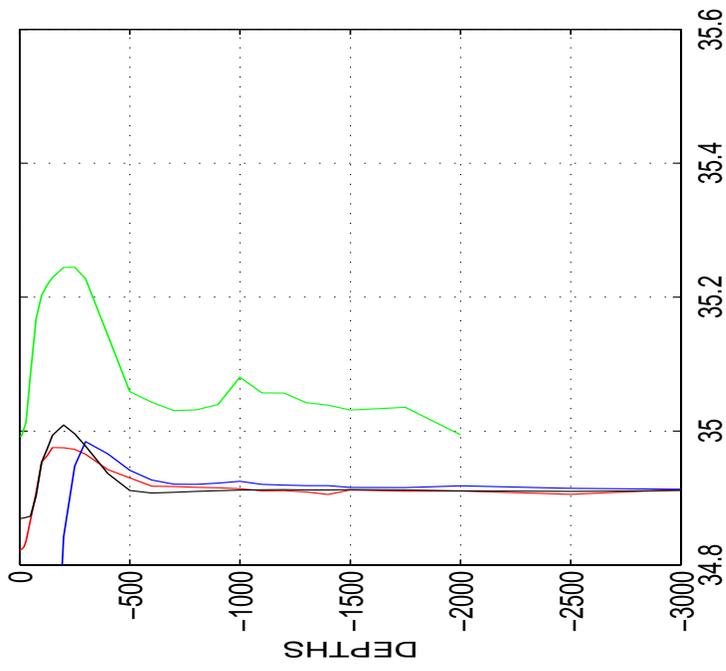




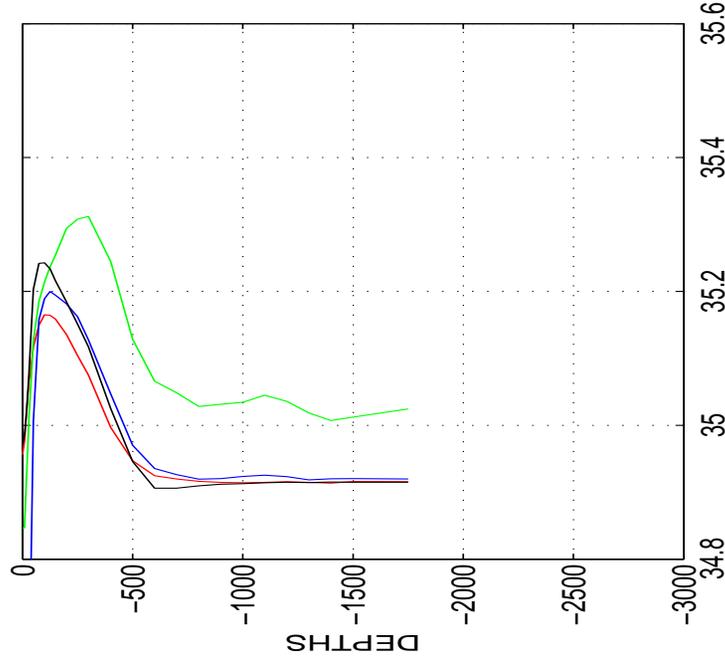
SALINITY (BLACK=OBS, RED=CLIM, BLUE=DIE, GREEN=POP)  
1987/5 TO 1987/6



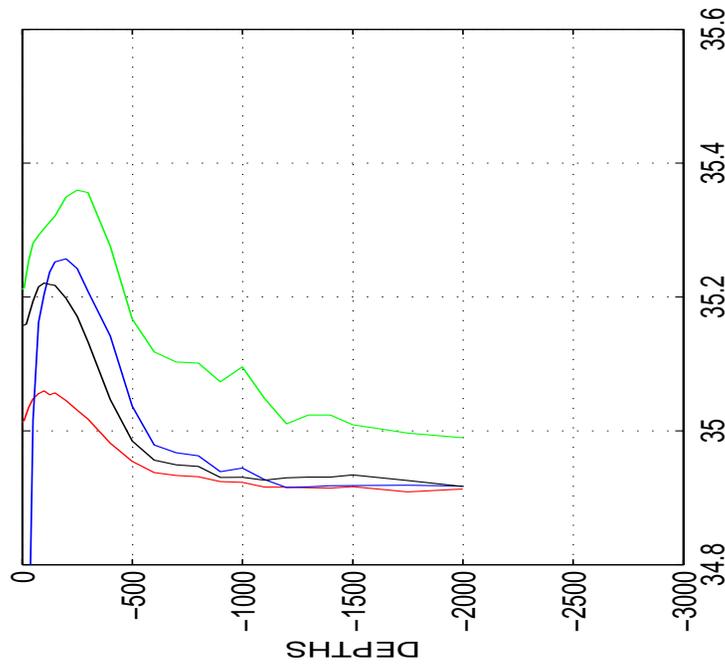
SALINITY (BLACK=OBS, RED=CLIM, BLUE=DIE, GREEN=POP)  
1988/11 TO 1988/11



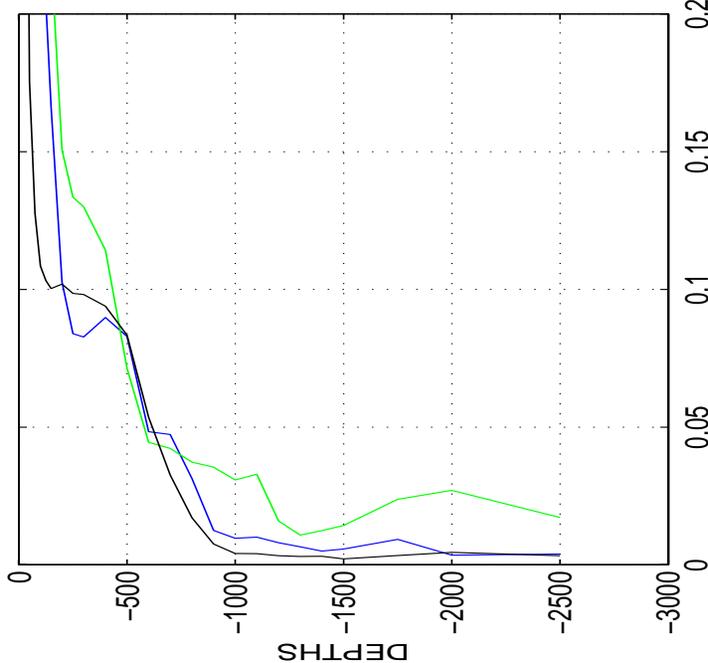
SALINITY (BLACK=OBS, RED=CLIM, BLUE=DIE, GREEN=POP)  
1987/9 TO 1987/9



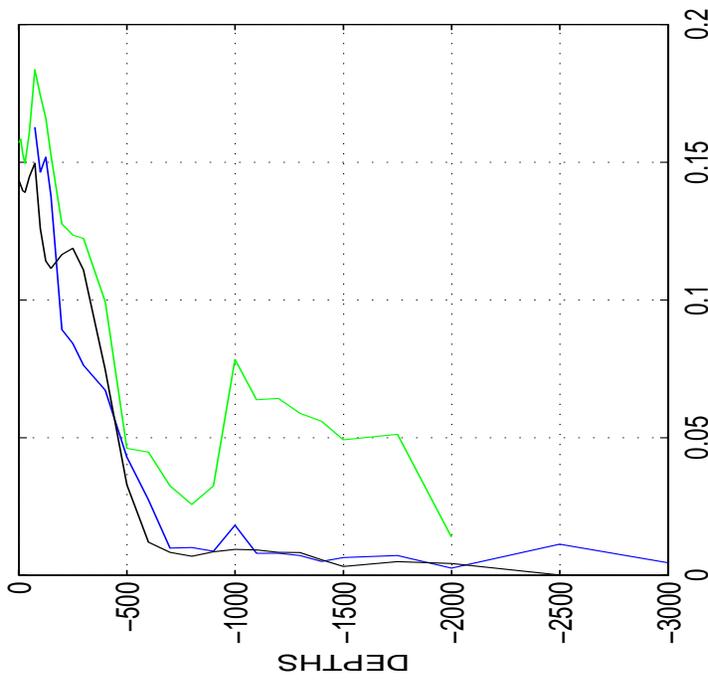
SALINITY (BLACK=OBS, RED=CLIM, BLUE=DIE, GREEN=POP)  
1986/6 TO 1986/6



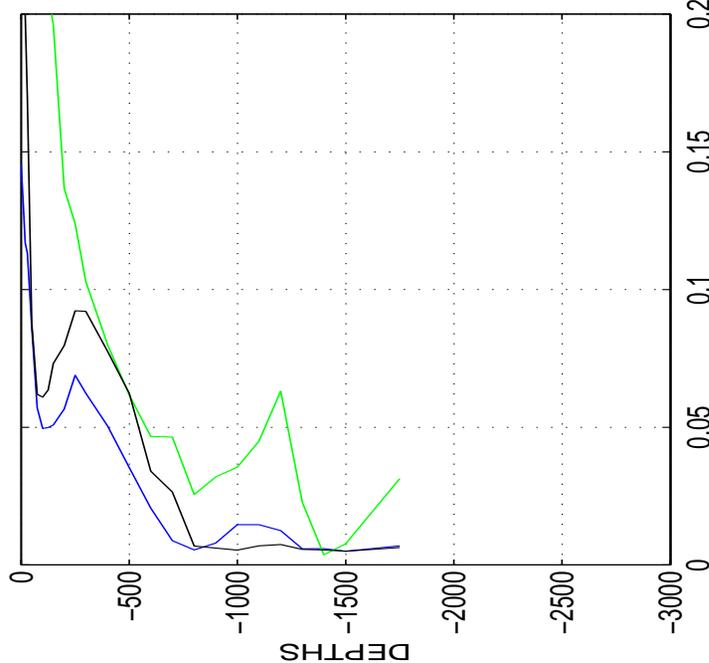
RMS SALINITY (BLACK=OBS, BLUE=DIE, GREEN=POP)  
1987/5 TO 1987/6



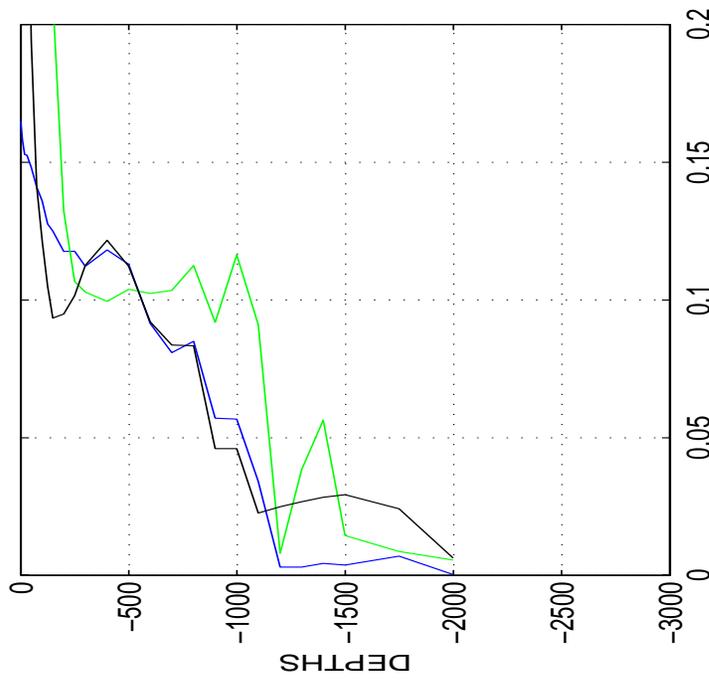
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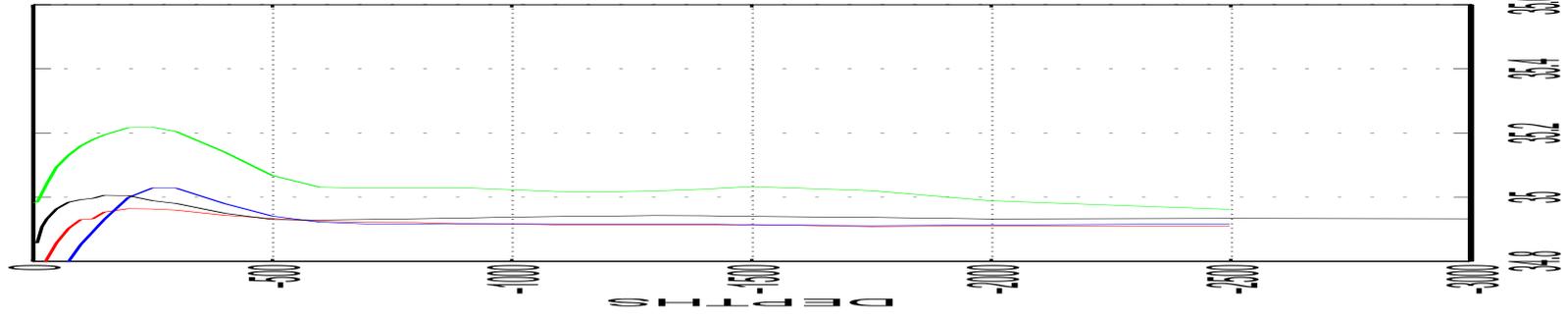


RMS SALINITY (BLACK=OBS, BLUE=DIE, GREEN=POP)  
1986/6 TO 1986/6



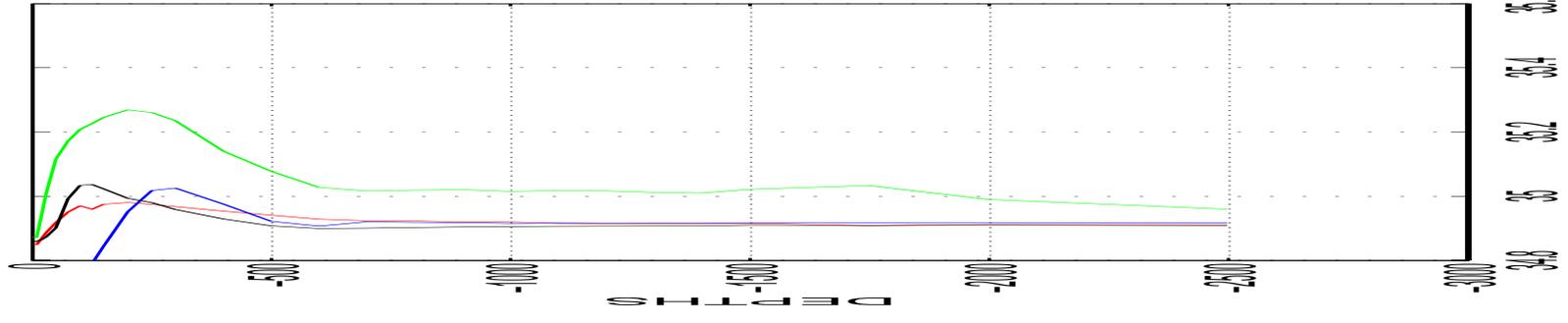
QUALITY BLACKS PER-CUM-BLUE-GREEN-POP

1980.5 TO 1980.6



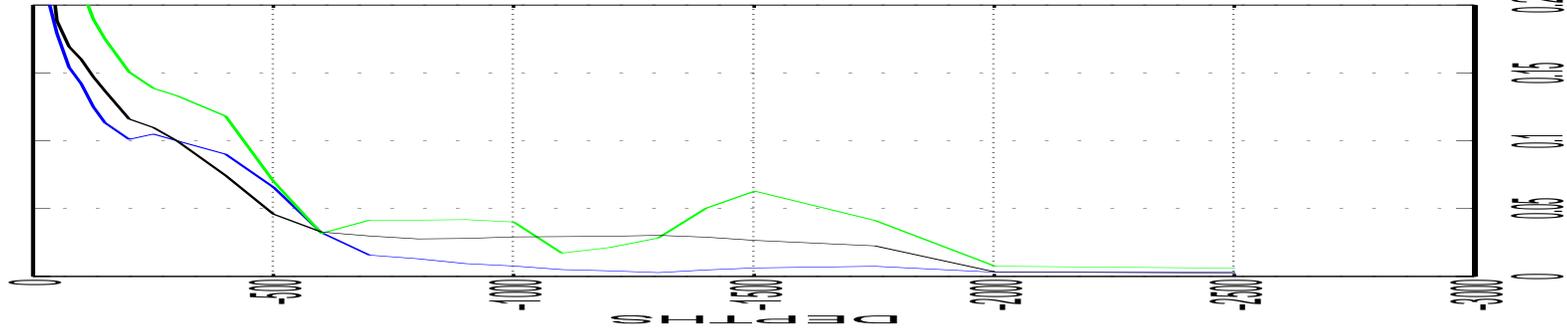
QUALITY BLACKS PER-CUM-BLUE-GREEN-POP

1980.7 TO 1980.8



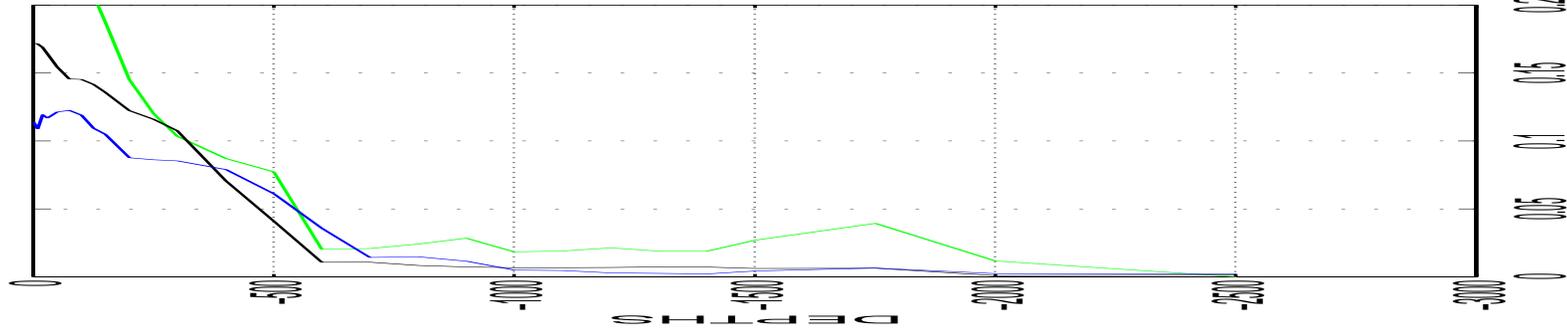
RMS SALINITY (BLACK=OBS,BLUE=DE,GREEN=POP)

1980/5 TO 1980/6

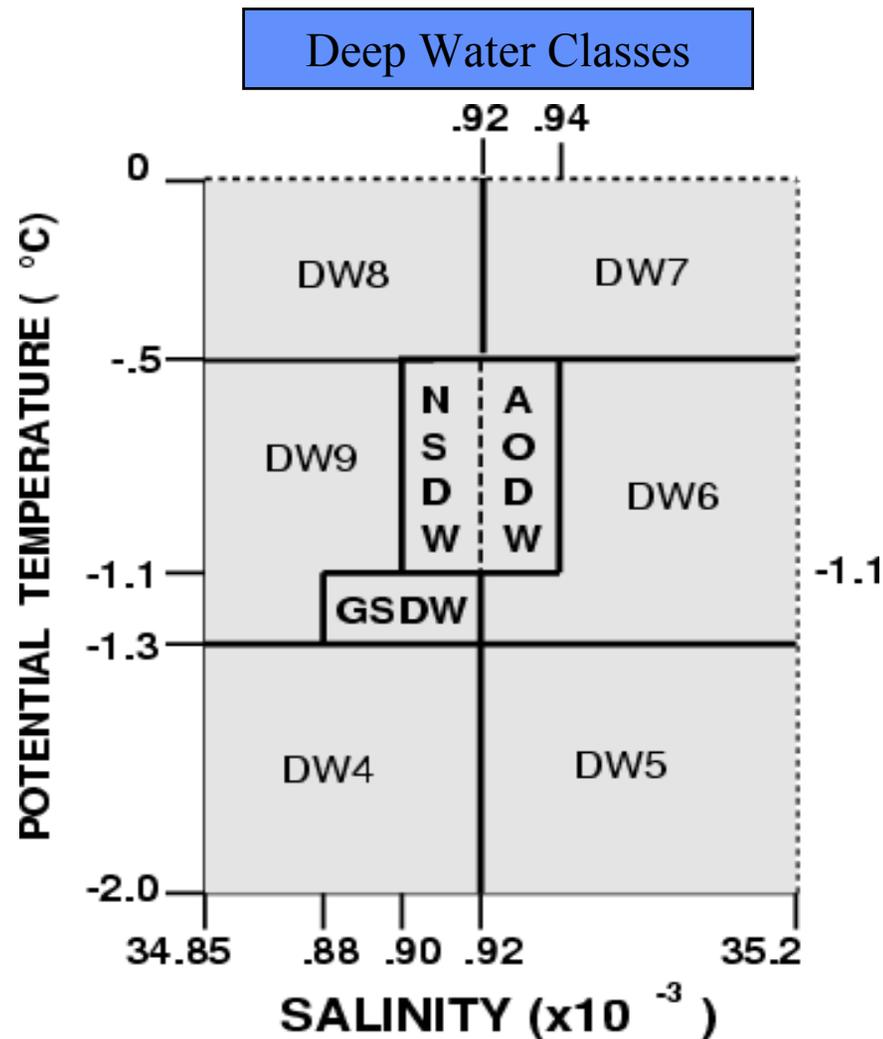
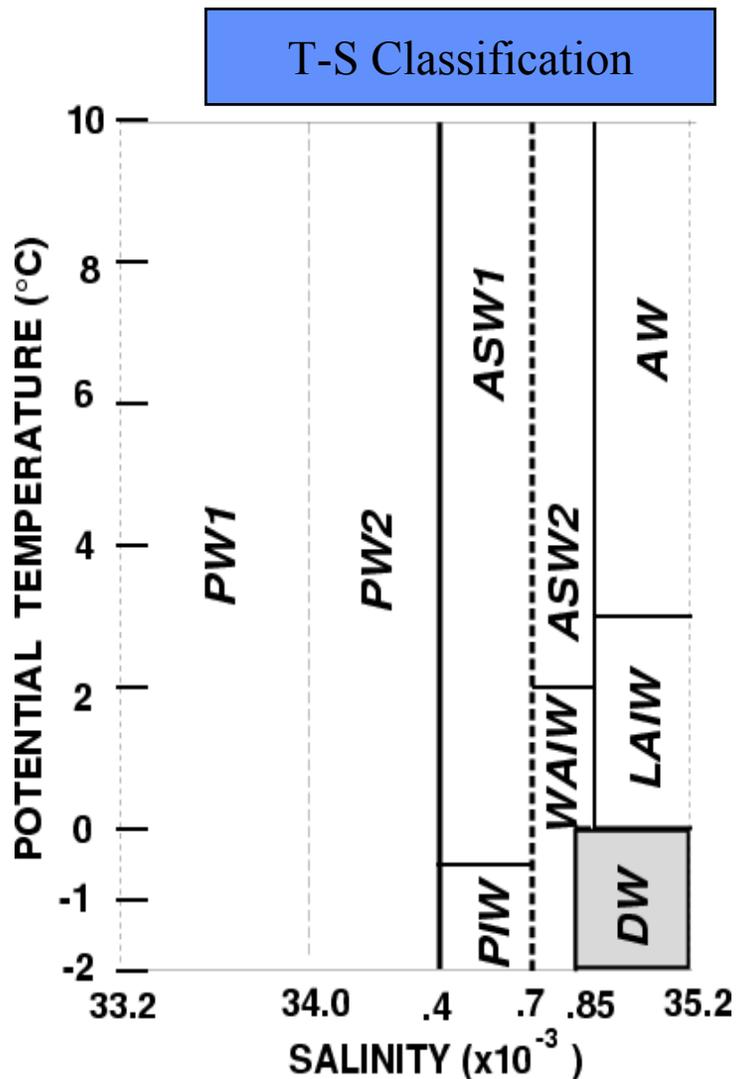


RMS SALINITY (BLACK=OBS,BLUE=DE,GREEN=POP)

1980/1 TO 1980/10



# FORMULATION AND APPLICATION OF METRICS FOR COUPLED MODELS



WATERMASS DISTRIBUTION (PERCENTAGES)  
 At the **1987 June CTD SURVEY** location and date  
 9W - 10E, 60N - 69N  
 [CTD, LEVITUS98, DIECAST, POP ]

•	CTD_lv	LEV98	DieCAST	POP13
• PW1	0.1	0.0	7.9	0.0
• PW2	0.0	0.0	1.5	0.0
• PIW	0.0	0.0	0.0	0.4
• <b>AW</b>	<b>29.6</b>	<b>15.8</b>	<b>22.3</b>	<b>12.9</b>
• ASW1	0.2	0.1	0.1	0.3
• ASW2	0.9	0.5	2.0	0.2
• UAIW	2.4	0.9	0.3	0.6
• <b>LAIW</b>	<b>10.3</b>	<b>33.1</b>	<b>12.4</b>	<b>55.7</b>
• <b>DW</b>	<b>56.7</b>	<b>49.9</b>	<b>51.3</b>	<b>30.0</b>

WATERMASS DISTRIBUTION (PERCENTAGES)  
At the **1987 June CTD SURVEY** location and date  
9W - 10E, 60N - 69N  
[CTD, LEVITUS98, DIECAST, POP ]

<b>DEEP W</b>	CTD_lv	LEV98	DieCAST	POP13
• <b>GSDW</b>	<b>12.2</b>	<b>10.5</b>	<b>13.2</b>	<b>0.0</b>
• <b>NSDW</b>	<b>35.3</b>	<b>27.1</b>	<b>18.7</b>	<b>0.0</b>
• AODW	0.1	1.1	6.5	2.0
• DW4	0.0	1.8	4.5	0.0
• DW5	0.0	0.0	0.0	0.0
• DW6	0.0	0.0	3.0	0.0
• <b>DW7</b>	<b>0.0</b>	<b>7.1</b>	<b>2.2</b>	<b>21.8</b>
• <b>DW8</b>	<b>9.1</b>	<b>2.7</b>	<b>2.9</b>	<b>0.1</b>
• DW9	0.0	0.0	0.2	0.1

**WATERMASS DISTRIBUTION (PERCENTAGES)**  
 At the **1987 September CTD SURVEY** location and date  
 9W - 10E, 60N - 69N  
 [CTD, LEVITUS98, DIECAST, POP ]

	CTD_lv	LEV98	DieCAST	POP13
• PW1	0.0	0.0	2.3	0.1
• PW2	0.1	0.1	0.5	0.1
• PIW	0.0	0.0	0.0	0.3
• <b>AW</b>	<b>44.1</b>	<b>41.3</b>	<b>39.6</b>	<b>13.2</b>
• ASW1	0.6	0.3	1.7	0.3
• ASW2	0.8	0.5	0.8	0.4
• UAIW	1.0	0.2	0.0	0.5
• <b>LAIW</b>	<b>12.6</b>	<b>19.4</b>	<b>17.2</b>	<b>55.6</b>
• <b>DW</b>	<b>41.0</b>	<b>38.3</b>	<b>38.0</b>	<b>29.7</b>

WATERMASS DISTRIBUTION (PERCENTAGES)  
At the **1987 September CTD SURVEY** location and date  
8W - 11E, 60N - 66N  
[CTD, LEVITUS98, DIECAST, POP ]

<b>DEEP W</b>	CTD_lv	LEV98	DieCAST	POP13
• GSDW	2.5	2.5	4.0	0.0
• <b>NSDW</b>	<b>25.0</b>	<b>23.2</b>	<b>15.8</b>	<b>0.0</b>
• AODW	2.9	0.5	7.9	1.9
• DW4	0.0	0.0	1.2	0.0
• DW5	0.0	0.0	0.0	0.0
• DW6	0.0	0.0	1.1	6.0
• <b>DW7</b>	<b>0.0</b>	<b>2.5</b>	<b>5.2</b>	<b>21.6</b>
• <b>DW8</b>	<b>9.9</b>	<b>9.6</b>	<b>2.8</b>	<b>0.1</b>
• DW9	0.0	0.2	0.0	0.0

WATERMASS DISTRIBUTION (PERCENTAGES)  
 At the **1989 June CTD SURVEY** location and date  
 21W - 5E, 60N - 69N  
 [CTD, LEVITUS98, DIECAST, POP ]

•	CTD_lv	LEV98	DieCAST	POP13
• PW1	0.0	0.1	1.5	0.0
• PW2	0.1	0.3	1.0	0.1
• PIW	0.4	0.0	0.0	0.2
• <b>AW</b>	<b>15.7</b>	<b>8.8</b>	<b>14.8</b>	<b>23.6</b>
• ASW1	1.5	1.5	4.3	0.2
• ASW2	2.8	1.9	3.2	0.2
• UAIW	5.3	5.2	5.3	0.5
• <b>LAIW</b>	<b>12.6</b>	<b>28.4</b>	<b>13.4</b>	<b>57.4</b>
• <b>DW</b>	<b>61.6</b>	<b>53.9</b>	<b>56.6</b>	<b>17.8</b>

**WATERMASS DISTRIBUTION (PERCENTAGES)**  
 At the **1989 June CTD SURVEY** location and date  
 21W - 5E, 60N - 69N  
 [CTD, LEVITUS98, DIECAST, POP ]

<b>DEEP W</b>	CTD_lv	LEV98	DieCAST	POP13
• GSDW	0.0	6.9	9.5	0.0
• NSDW	<b>1.2</b>	<b>30.6</b>	<b>25.2</b>	<b>0.0</b>
• AODW	<b>32.4</b>	<b>2.5</b>	<b>5.3</b>	<b>1.0</b>
• DW4	0.0	0.0	3.1	0.0
• DW5	0.0	0.0	0.6	0.0
• DW6	11.1	0.0	1.6	3.7
• <b>DW7</b>	<b>10.2</b>	<b>6.8</b>	<b>3.2</b>	<b>12.8</b>
• <b>DW8</b>	<b>6.3</b>	<b>7.1</b>	<b>8.0</b>	<b>0.1</b>
• DW9	0.2	0.0	0.2	0.1

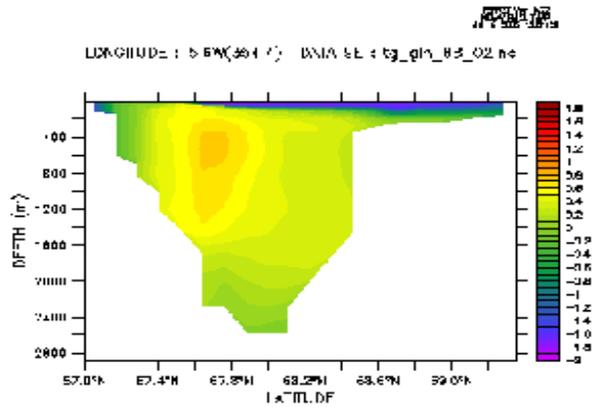
**WATERMASS DISTRIBUTION (PERCENTAGES)**  
 At the **1989 September CTD SURVEY** location and date  
 13W - 4E, 62N - 67N  
 [CTD, LEVITUS98, DIECAST, POP ]

	CTD_lv	LEV98	DieCAST	POP13
• PW1	0.0	0.0	1.8	0.0
• PW2	0.0	0.0	2.3	0.1
• PIW	0.0	0.0	0.0	0.1
• <b>AW</b>	<b>17.5</b>	<b>22.8</b>	<b>12.6</b>	<b>23.7</b>
• ASW1	0.9	0.5	4.4	0.3
• ASW2	5.6	2.2	4.8	0.3
• UAIW	7.5	0.5	3.4	0.5
• <b>LAIW</b>	<b>10.5</b>	<b>19.9</b>	<b>14.1</b>	<b>57.5</b>
• <b>DW</b>	<b>58.2</b>	<b>54.2</b>	<b>56.8</b>	<b>17.4</b>

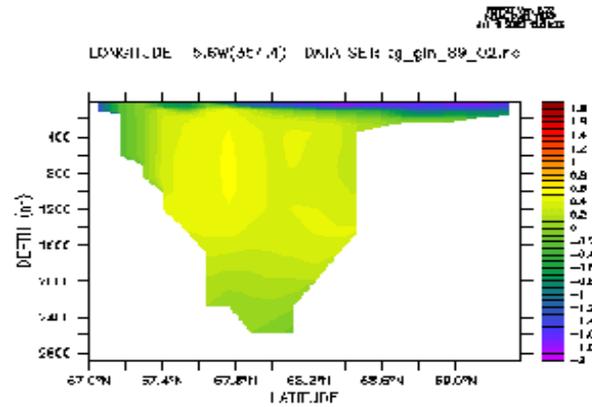
**WATERMASS DISTRIBUTION (PERCENTAGES)**  
 At the **1989 September CTD SURVEY** location and date  
 13W - 4E, 62N - 67N  
 [CTD, LEVITUS98, DIECAST, POP ]

<b>DEEP W</b>	CTD_lv	LEV98	DieCAST	POP13
• GSDW	6.4	5.5	12.1	0.0
• <b>NSDW</b>	<b>33.9</b>	<b>29.2</b>	<b>28.6</b>	<b>0.0</b>
• AODW	0.0	4.6	3.8	1.0
• DW4	0.0	0.0	1.3	0.0
• DW5	0.0	0.0	0.0	0.0
• DW6	0.0	0.0	0.6	3.8
• <b>DW7</b>	<b>0.0</b>	<b>1.9</b>	<b>2.1</b>	<b>12.4</b>
• <b>DW8</b>	<b>12.7</b>	<b>13.1</b>	<b>6.8</b>	<b>0.1</b>
• DW9	5.2	0.0	1.5	0.1

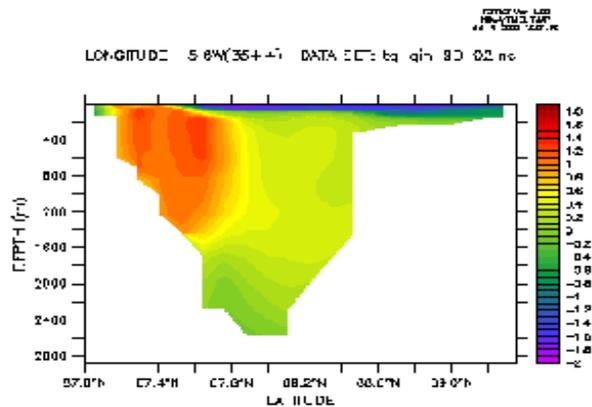
# Temperature Variations in Fram Strait 1988-1991



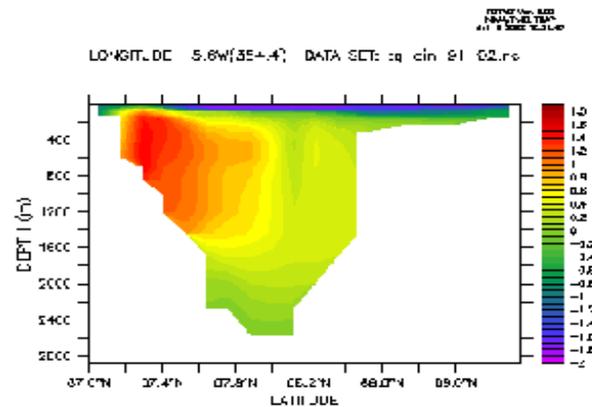
T\_Feb\_03\_GIN (deg)



T\_Feb\_09\_GIN (deg)

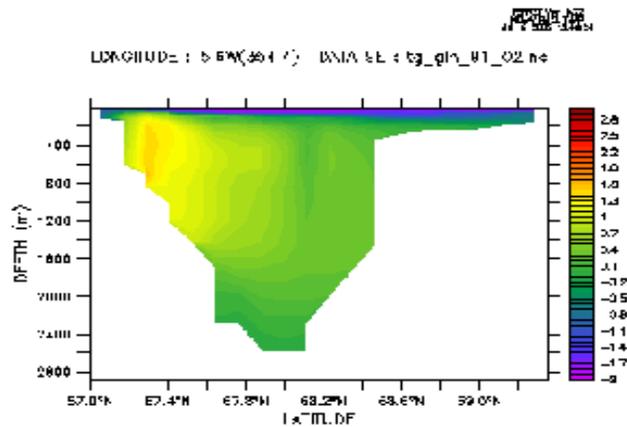


T\_Feb\_00\_GIN (deg)

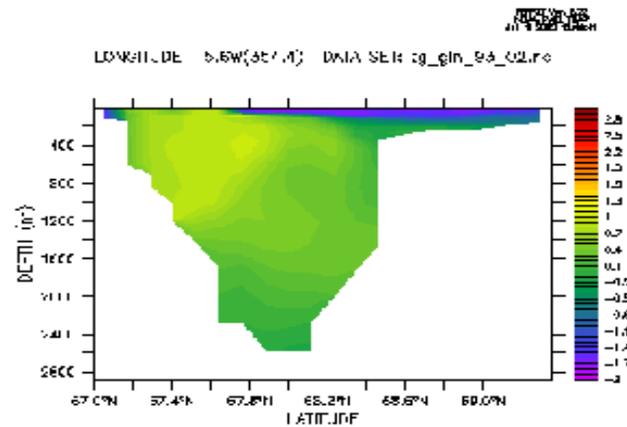


T\_Feb\_01\_GIN (deg)

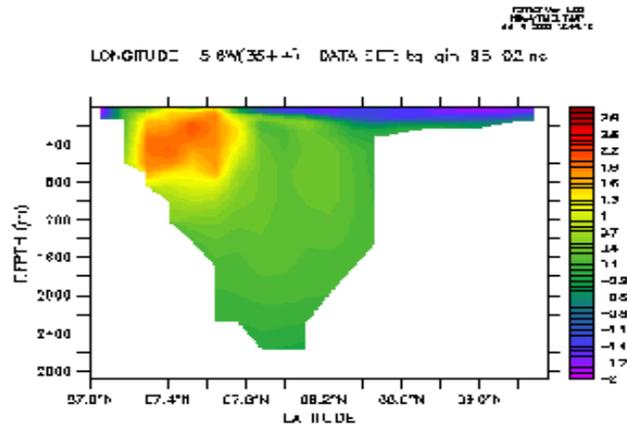
# Temperature Variations in Fram Strait 1991-1997



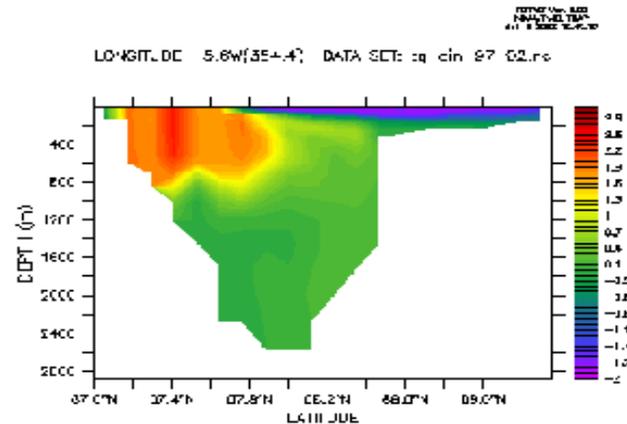
T\_Feb\_91\_GIN (deg)



T\_Feb\_93\_GIN (deg)



T\_Feb\_95\_GIN (deg)



T\_Feb\_97\_GIN (deg)

**DECADAL VARIABILITY OF FLOWS  
INTO AND OUT OF THE GIN/BARENTS SEAS  
[for month of February, POP model]**

	T80	T90	V80	V90	H80	H90
	(deg C)		(SV)		(°C-SV)	
NAWI	6.9	7.3	6.2	7.6	46.2	58.7
NS	7.3	7.5	*	*	*	*
WSP	0.7	1.5	3.4	5.0	.33	.46
SV-FJL	0.35	0.43	*	*	*	*
ZEML	0.1	0.3	3.4	3.4	.26	.37

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\* - flows going south

# DECADAL BEHAVIOR OF VOLUME TRANSPORTS ACROSS 63N, 4W to 6E

POP average for

1980's      1990's (in Sverdrups)

- NET VOLUME TRANSPORT  
**3.33      3.86**
- TRANSP OF AW [ $T > 3^\circ$ ,  $S > 34.90$ ]  
**2.72      3.22**
- VOLUME OF INFLOW [ $V > 0$ ]  
**4.56      5.07**

# CONCLUSIONS

- **The models beat long-term ‘persistence’ [climatology] in all years**
- **The metrics making optimal use of high quality hydrographic data were very useful in exposing model drifts**
- **Lack of interactive ice model did not seem to bother either model in the area and period of the test**
- **POP had excellent prediction above 500m but had a serious bias for both T and S below 700m (traced to accelerated spinup below 1000m, no longer used)**
- **DieCAST had excellent prediction below 200m, but had a serious bias in S (too fresh) in the top 200m (traced to faulty forcing)**